Proposed Modelling Assessment of Environmental and Ecosystem Contamination of the Animas River from the Gold King Mine Chemical Release

Situation

Approximately 1 to 3 million gallons of mine waste were accidentally released into a tributary of the Animas River (Cement Creek) on August 5, 2015. Since that time, a plume of contaminated slurry has been working downriver affecting reaches in SW Colorado and New Mexico. By August 11, the plume had traveled 80 miles with significant visual impact, and contamination of water sources and river ecosystems as it moved downstream. Some release may still be occurring from the source. The impact zone will continue to grow.

The mine waste sludge contains numerous chemicals and metals, some of which can be toxic to aquatic ecosystems and humans with sufficient exposure. EPA is currently sampling for TAL Metals + Molybdenum. The sampled constituents include: Al, Ca, Fe, K, Mg, Na, Sb, As, Ba, Be, Cd, Cr, Co, Cu, Pb, Mn, Mo, Ni, Ag, Se, Tl, V, Zn, and Hg.

Key Exposure Questions

Impacts on aquatic ecosystems are possible given the nature and concentration of chemicals in the waste water. Exposure modeling can be used to predict spatial and temporal impacts over the short and long term. Initial questions that can be addressed with available models include:

- How far downriver will contamination travel?
- How long will chemicals remain in the water?
- How much chemical will sequester in the sediments along the river reach?
- How long will chemicals persist in the sediments?
- Will chemicals stored in sediments leak to the water over time?
- How much chemical may accumulate in fish?
- Are toxic levels for fish or human consumption reached?
- How will chemicals affect aquatic communities?
- Can wells in river alluvium become contaminated from the contaminants in the river?

Based on the preliminary list of chemicals and initial concentrations reported, experts from ERD suggest an initial series of hypotheses.

- Chemicals are likely to be strongly bound to the clay particles in the slurry.
- How far each chemical will travel will depend on the volume of clay. The likely plume distance will match the distance that clay will travel. Current coloration in the river could be iron hydroxide rather than clay, which will determine the most relevant transport processes.
- Clay is likely to remain in suspension with velocities in the main river for some distance.
- The release probably drove pH down. As the plume dilutes downstream, and pH increases, the material will precipitate out (hydroxides, etc.) and deposit in the slower zones of the river.

- Chemicals will settle onto the surface of the streambed. These materials may become buried in the sediments surface as material settles out. Chemicals will sorb to clay particles, which will then settle to the streambed.

- Benthic organisms will be exposed to chemicals, and those closest to the spill may initially be heavily impacted (including mortality) through exposure or burial.

- There may be secondary (flow-driven) chemical release through resuspension of the clays. This could occur as either constant or pulses of low grade chemical concentrations for some time after the initial plume passes with sediments as the dominant source.

- Some chemicals on the list could be toxic to benthos or humans (consult further with NHERL).

- Wells in shallow alluvium next to the river could draw water from the river into the alluvium that could bring contaminants into wells. Such wells should not be pumped during passage of the plume. Whether secondary pulses in the river would be sufficient to contaminate wells is less clear.

Proposed Model Application

Models to Deploy

ERD proposes to model potential exposure to chemicals of interest by modeling environmental and biological concentrations of contaminants in the river over time.

- WASP: Environmental concentrations in water and sediments will be modeled with water quality model **WASP** This model can address river systems with multiple layers of sediment.

- BASS: Biological concentrations in fish and benthic organisms will be modeled with **BASS**. Estimated chemical concentrations in game fish can be used to assess human dietary exposure.

Chemicals to Model

A preliminary examination of the list of chemicals that would probably be most useful to model from a fate and transport and/or potential toxicity viewpoint include:

Zinc, cadmium, silver, copper, aluminum, arsenic, iron, mercury, lead

Sampled Chemical/River Data

A list of chemicals currently sampled was provided to ERD. In addition to some of these chemicals, the following data would be helpful given its importance in determining chemical transport and for model validation.

Water Quality:

Water column sampling assumptions:

- Sampling stations will be established along the river reach of interest (currently there appear to be 6 sites)
- Chemical concentrations (currently 23 tested) will be sampled for some period of time, including after the plume as passed

Additional data that would be useful for modeling (necessary for high reliability)

In the river reach of interest:

- Sulfate, sulfide, and sulfur (not on list of currently measured)
- pH and temperature
- DOC, TOC
- Start measuring bed sediments if not done so far. Sediments will be source loading for longer term modeling projections. Standard particle size assessment.
- Sediment concentration in water (TSS), particle size
- River width, depth. These may be obtained from NHD type data
- Chemical concentrations in bed sediments
- Fish community composition and biomass of benthic fauna (pre-spill)
- Are there wildlife (fish) reports, data regarding kills, body concentrations (post-spill)

At Source of Plume:

Volume of material released, when released, duration.

Research/Modeling Approach:

- Identify river reach of interest (no spatial limits, can be quite extensive)
- Setup project: obtain necessary modeling data, define reaches, calibrate WASP. Parameterize from available USGS data. Fairly standard model setup and implementation. Minimize complexity of hydrology, etc.
- BASS straight forward to setup once WASP is set up. Obtain appropriate aquatic community information
- Simulate concentrations of sediment and concentrations of elements of concern in the water column and several sediment layers throughout the length of the reach. Model over some lengthly period of time to address resuspension concerns.
- Validate as possible with data available from EPA or other agency sampling
- Link exposure concentrations to benthic and fish communities using BASS. Base interpretations on fish body residue. Can translate to human consumption advisories for chemicals with known reference doses (e.g. Hg, lead, etc)
- Groundwater modeling (e.g. GFLOW) could be employed to determine the capture zone of vulnerable wells.

Projected Timeline:

Setting up the project: less than a month to set up. Some aspects may become more complicated as we set it up; level of attack; etc.

Product: Agency preliminary briefings and report: 1 to 2 months

Rely heavily on previously published papers and reports for methods descriiption

Exposure Modeling Project Team:

Chris Knightes	WASP modeling (existing SSA support)
Craig Barber	BASS modeling (existing SSA support)
Steve Kraemer	Groundwater advice, GFLOW modeling
Kate Sullivan	report assistance, etc.